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G06K 19/077

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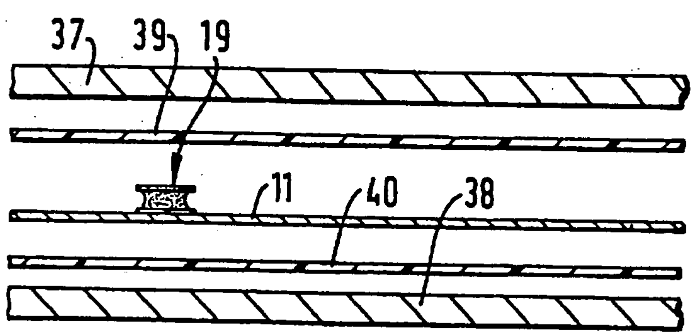
(56) Documents Cited
GB 2225283 A EP 0488574 A2 EP 0216366 A2
US 4966857 A

(58) Field of Search
UK CL (Edition L) B6A AK
INT CL[5] G06K

(54) **Integrated circuit or smart card.**

(57) A smart card comprises a printed circuit 11 sandwiched between outer protective layers 37 and 38 with intervening layers of reinforcing material 39 and 40, typically of a material such as polyester. During fabrication an integrated circuit component 19 on the card deforms the reinforcing material 39 and embeds itself in protective layer 37 which is softened during the manufacturing process. Once fabricated the reinforcing layer 39 prevents the component 19 "breaking out" of the outer protective layer. The reinforcing layers 39, 40 are coated on both sides with a thermally activated catalytic curing adhesive which bonds the protective layers to the printed circuit 11 and the outer protective layers 37, 38.

FIG. 11



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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

FIG. 1

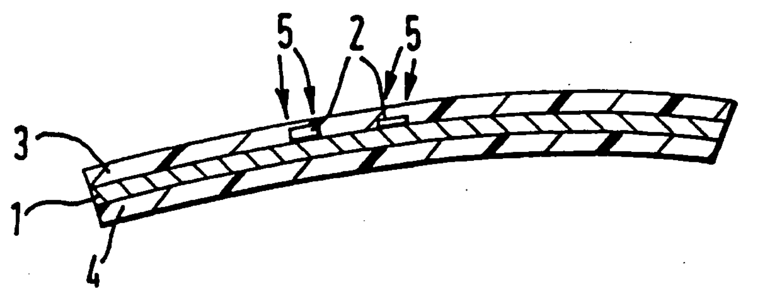


FIG. 2

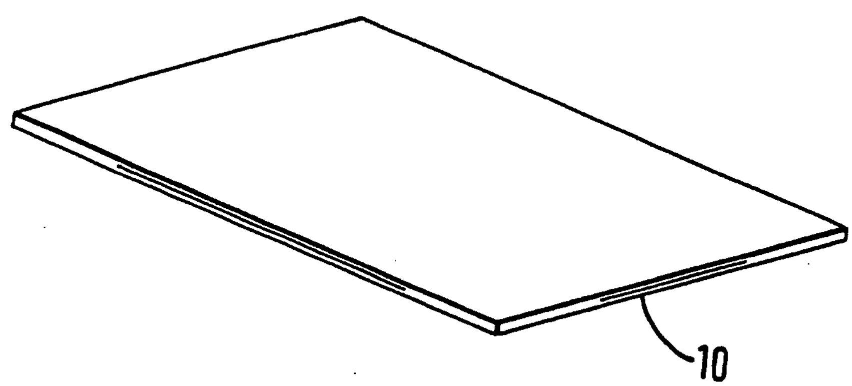


FIG. 3

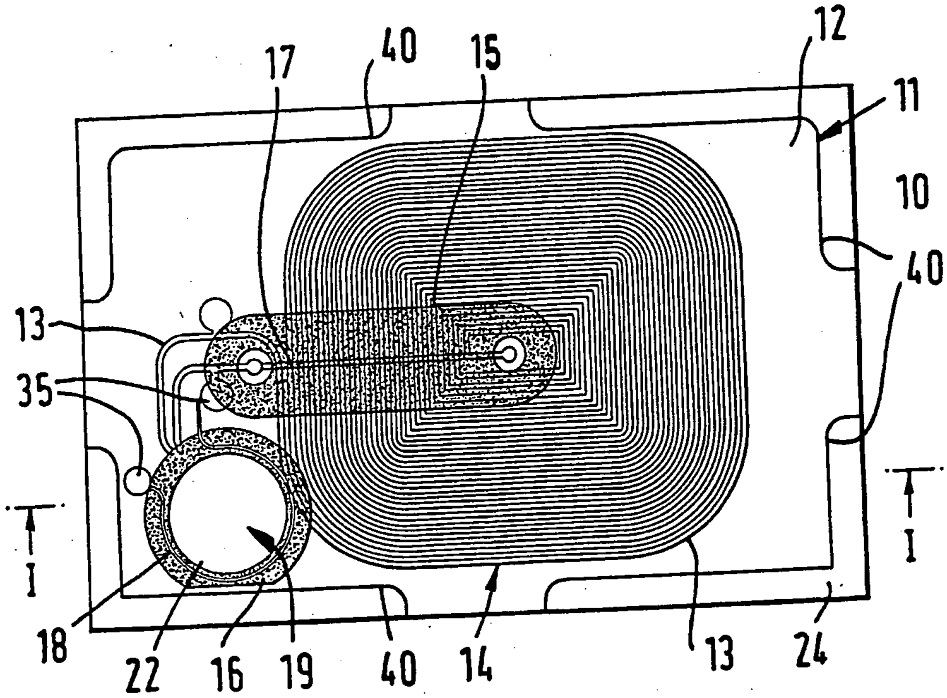

17
40
15
12
11
10
40
13
35
I
I
18
22
16
19
40
14
13
24

FIG. 4

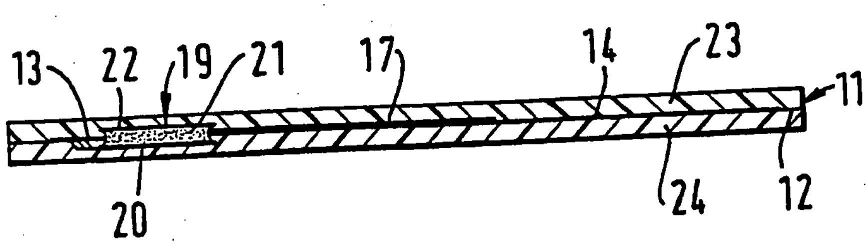
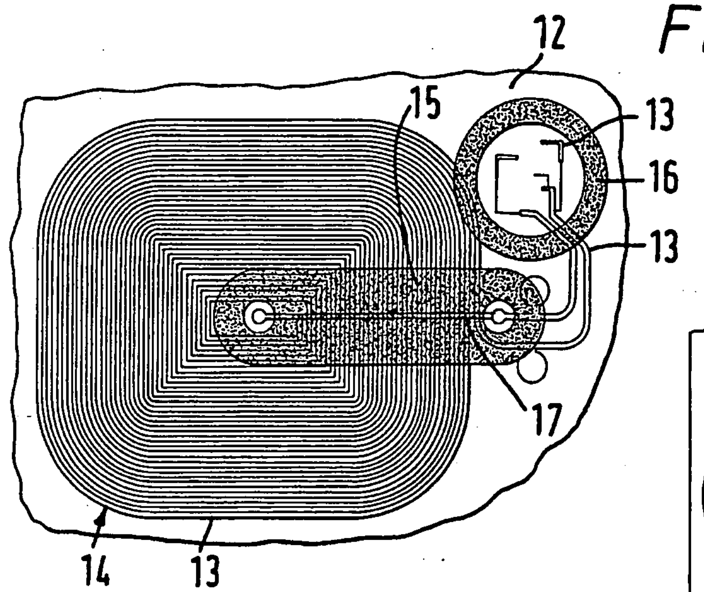

13
22
19
21
17
14
23
11
20
24
12

FIG. 5



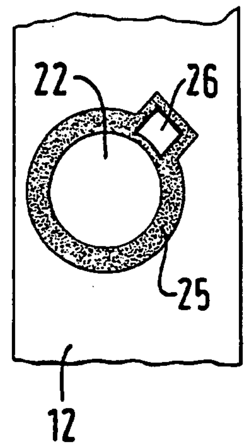


FIG. 6

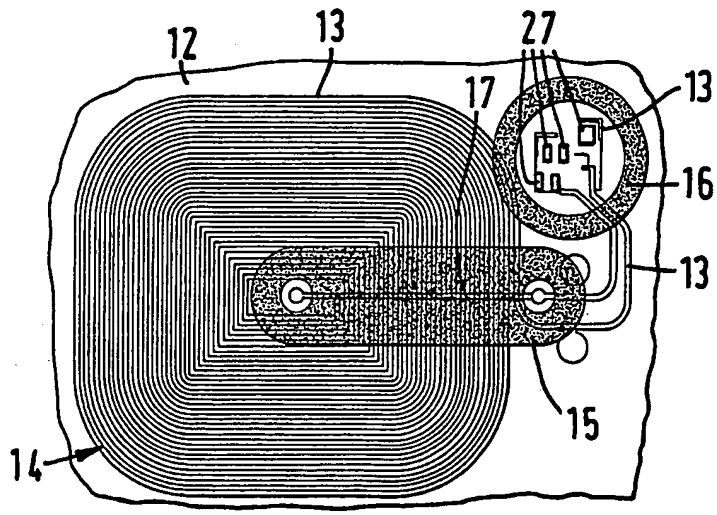


FIG. 7

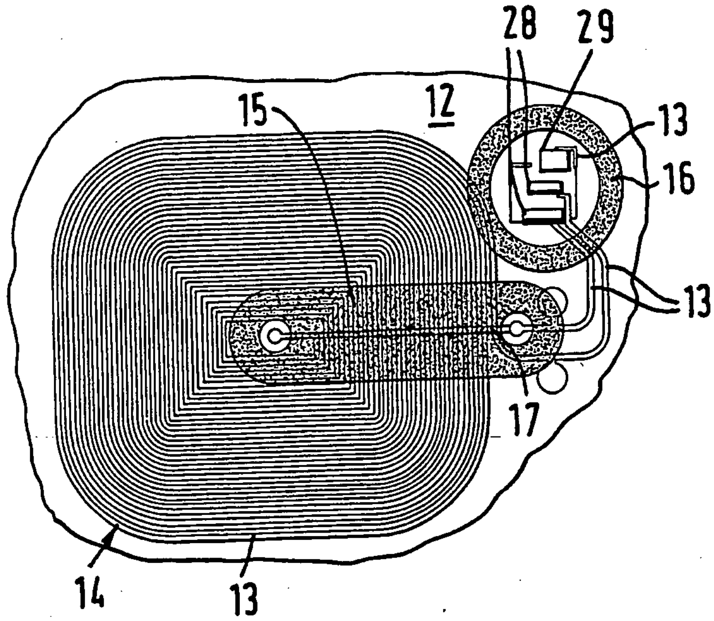


FIG. 8

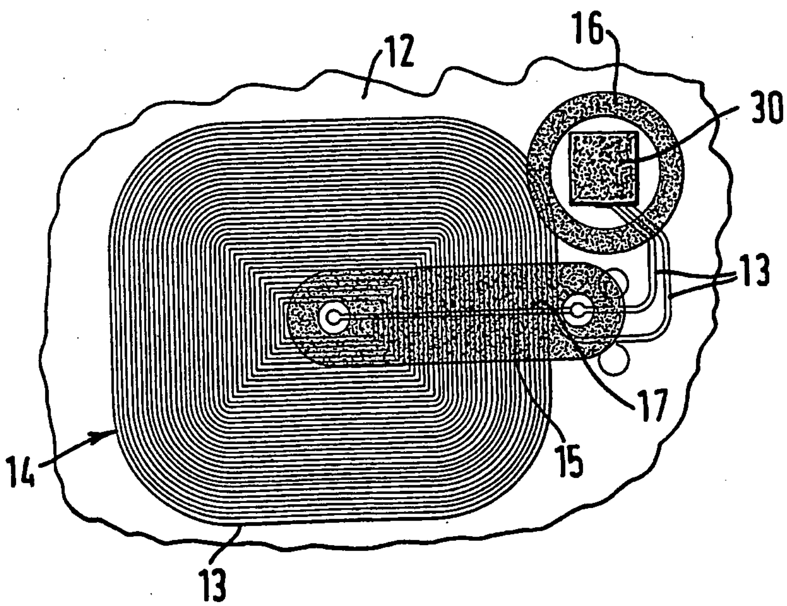


FIG. 9

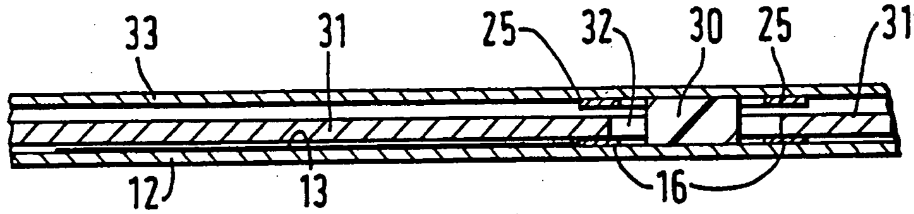


FIG. 10

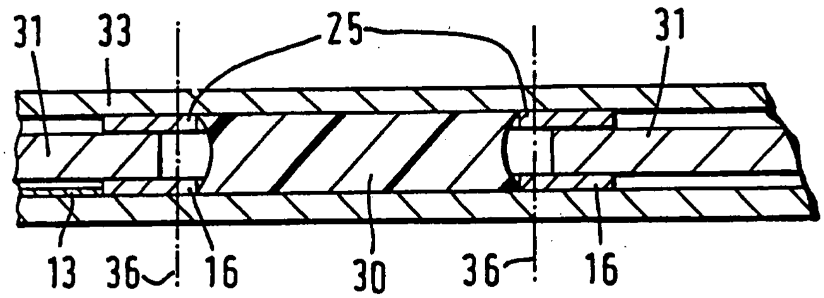
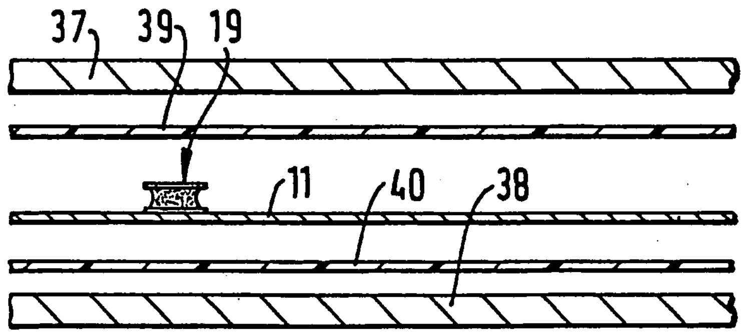


FIG. 11



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A FLEXIBLE CARD

This invention relates to a flexible card comprising a printed circuit sandwiched between outer protective layers and in particular but not exclusively to what are commonly referred to as "plastic cards", that is cards which are carried by individuals and used for such purposes as recording or authorising transactions and/or for authorising entry to buildings or parts thereof. (Note that the term "printed circuit" as used in this specification should be considered to refer to any system of conductive tracks on an insulating substrate, whether such tracks are formed by printing, etching, vapour deposition or any other technique.)

It has previously been proposed to manufacture such cards as schematically illustrated in Figure 1. A printed circuit 1 carrying components 2 is sandwiched between protective layers 3 and 4, in layer 3 of which the components 2 are embedded during the manufacturing process by heating and softening the layer which is typically pvc. However a problem has been encountered with this in that the components 2 tend to break out of the pvc at regions 5 when the card is subjected to bending, which such a thin card inevitably receives in everyday use.

According to the present invention there is provided a flexible card comprising: a printed circuit; outer protective layers in which the printed circuit is sandwiched; and a sheet of reinforcing material located between the circuit and one of the protective layers. Such a layer, which may advantageously be polyester, should be soft enough

to enable the components to embed in the outer protective layer during the manufacturing process but be resistant to tearing thereby preventing the component breaking through the reinforcing layer and out of the card.

Preferably the reinforcing layer is coated in adhesive which bonds a protective layer to the printed circuit and if this is a thermally activated catalytic curing adhesive this speeds up the manufacturing process, for the adhesive will continue to cure after being removed from a source of heat, as compared with other adhesives which only cure while heat is applied, the cure time being quite long in the case of most adhesives suitable for this purpose. Advantageously such a reinforcing layer is provided between each of the protective layers and the printed circuit as it enables the complete structure to be bonded together. The invention is particularly advantageous if one or more components are encased in a relatively hard material to form an element, for although such an element is protective of the components within it, it provides a rigid member within an otherwise flexible card and such elements are particularly susceptible to breaking out of plastic cards.

According to a second aspect of the invention there is provided a method of fabricating a printed circuit having components thereon comprising: sandwiching the printed circuit between inner layers of flexible reinforcing material and outer layers of protective material; and heating the layers such that the outer material softens allowing the components to become embedded in it. Preferably the reinforcing layers are coated with adhesive which bonds the protective layers to the printed circuit.

One embodiment of the invention will now be described, by way of example only, with reference to Figures 2 to 11 of the accompanying drawings in which like numerals have been used to indicate like parts, and of which:

Figure 1 schematically illustrates a previously proposed arrangement (not in accordance with the invention) of electrical components in a plastic card;

Figure 2 is a perspective view of a plastic card in accordance with the present invention;

Figure 3 is a plan view of the card of Figure 2 having its top sheet 4 removed to reveal the printed circuit;

Figure 4 is a cross-section through the card along the line I - I of Figure 3; and

Figures 5 to 11 illustrate various stages in the production of the plastic card depicted in Figures 2 to 4.

Referring first to Figure 2 there is shown a perspective view of the final card which has the same external dimensions as a standard "plastic card". The card contains an integrated circuit. On Figure 2 it is possible to see edge portions of a substrate of the integrated circuit, exposed at a central part of each edge of the card. The integrated circuit communicates with interrogation units via an inductive link

located at appropriate locations. The integrated circuit would normally contain a memory device and could be used for any number of purposes, for example recording banking transactions or recording zones of buildings etc to which entry has been gained by use of the card as an identity card.

Referring to Figure 3 there is illustrated a plan view through a section of the card 10 of Figure 2 in the plane of the card. From this and the cross-section along line I - I illustrated in Figure 4 it can be seen that a printed circuit 11 comprises epoxy/glass substrate 12 and conductive tracks 13, a substantial portion of which form conductive loop 14. Darkly shaded regions 15 and 16 comprise of a thermoset dielectric material. The purpose of the region 15 is to insulate a silver conductor 17 from the inductive coil 14. The purpose of dielectric layer 16 will be explained later.

An integrated circuit and capacitive components, not shown in Figures 3 or 4, are contained within a capsule-like element 19 which is separated by cut 18 from the rest of the substrate 12. The region 20 of the substrate 12 is lowered below the plane of the printed circuit 11, the integrated circuit and capacitive components being located in potting compound 21 sandwiched between the portion of the substrate 20 and a capping portion 22 of the same material as the substrate 12.

The printed circuit 11 and element 19 are sandwiched between two outer sheets 23 and 24 of PVC thermoplastics material and two intervening layers (not shown in Figures 3 or 4), of polyester which is coated on both sides with a thermally

activated catalyst adhesive by which the laminated structure is adhered. This polyester acts as a reinforcing layer preventing element 19 "breaking out" of the PVC layers 23 and 24.

The fabrication process of the card illustrated in Figures 2, 3 and 4 begins with a substrate sheet 12 of copper-clad epoxy/glass which is etched to form a large number of identical printed circuits 13, each as illustrated in Figure 5. On top of each printed circuit is printed a thermoset dielectric material indicated by the shaded regions 15, 16 which is cured in place. The function of circular part 15 is explained below. The linear part 16 serves as an insulator to separate printed conductive link 17 between inner and outer ends of a coil 14 defined by part of the printed circuit 13. Separated from a main part of the substrate by lines of weakness not shown are a number of strips (not shown), each carrying printed patterns 25 (only one of which is illustrated), with apertures 26 therein, which ultimately become the top reinforcing caps of the elements 19.

The substrate carrying the etched patterns is placed on a bed of a screen printing machine (not shown) and a screen placed over it. A squeegee is then used to print a low ionic epoxy encapsulant/adhesive material onto positions 27 as shown in Figure 6. This is a mixture of a resin and a catalyst which sets hard when cured. Suitable materials are, for example, available from Ablestick, Encaremix, or Dexter Hisol. The substrate is then placed in a "pick-and-place" machine which places components comprising of capacitors 28 and silicon chips 29, shown in Figure 7, onto

the epoxy which acts as an adhesive to hold them in place. The silicon chips 29 at this stage are "naked", that is to say they are not encapsulated. A notable feature of this process is that the epoxy is applied to areas where there is no copper layer, this being unnecessary because of the adhesive attachment of the components. A saving of 35 microns in thickness is thus achieved as compared with arrangements where components are soldered on top of a copper track. It will be appreciated that this reduction of thickness may be of crucial importance in situations where there may typically be a requirement for the entire assembly not to exceed 760 microns. An advantage of using epoxy adhesive is that if suitably selected it remains in its adhesive state for a sufficient time period which exceeds the maximum period during which the screen printing machine is not being operated. This avoids the need to clean down the equipment.

The sheet substrate carrying the etched patterns and respective components positioned on it, is then baked until the epoxy has gelled, i.e. set but not hardened. This takes place under a flow of nitrogen to prevent oxidation of the copper. The sheet is then placed on the work-holder of a wire bonding machine where it is held in position by a vacuum. Suitable machines for this purpose are commercially available. Wire connections are then made between contacts on the individual components to appropriate parts of the printed copper circuitry. This is done by an ultrasonically assisted diffusion welding process. The sheet is then placed back in the screen printer with a different stencil in place. This stencil is much thicker, its thickness being selected so that the same epoxy encapsulant/adhesive now to be deposited over the

components is sufficient to cover them completely. Notably, this material is the same as that which was used for the adhesive. It does not have to be the same but it preferably has similar physical characteristics. After the removal of the stencil, the sheet is as shown in Figure 8, the components being encapsulated by the encapsulant 30.

Figure 9 shows in cross-section the next stage of the process where a copper spacer 31 having a plurality of apertures 32 (corresponding to each of the regions on the sheet having encapsulant 30 deposited thereon) is located on the sheet, 12. Previously placed on the copper sheet is each of the now separated strips 33, previously referred to, to form regions defined by printed patterns 25, from which regions reinforcing caps 22 will be formed. The spacer 31, with strips 33 located on it by means of pins (not shown for clarity), has been placed on top of the substrate. The whole arrangement is then pressed such that the patterns 25 are pressed into contact with the spacer 31 which is thus pressed closely down onto the circular part 16 of the dielectric material. It also presses the portions of the strip 33 defined by the patterns 25 onto the, still soft, epoxy encapsulant/adhesive thereby pulling the entire assembly down to the desired height. During this process the encapsulant spreads out as shown in detail in Figure 10, but not as far as the edges of the spacer sheet. It is prevented from doing so by its meniscus acting against the inner edges of the copper pattern 25 and dielectric ring 16, which meniscus thereby defines the radius of the encapsulant.

The whole assembly is now placed in an oven and cured at a temperature of 150°C. This fully gels the encapsulant/adhesive both under the components and the encapsulant portion. The assembly is now placed on a rule die which forms cuts 34 which can be seen in Figure 3. These cuts are "horseshoe-shaped" and configured so that their free ends correspond with the slots 26 (see Figure 5) in the strip 33. Note at this stage that the ends of each cut are located on the copper pads 35 of Figure 3. The cutter presses through the structure as illustrated by dotted lines 36 in Figure 10, leaving the element 19 on a limb of the substrate 11, as is best seen from Figure 3, and leaving the spacer 31 and remaining portions of the strips 33 free to be removed.

It will be noted from Figure 3 that the electrical connections to the element run parallel to an edge of the card, in which direction the card is most resistant to bending, as opposed to across the hinge line which runs across the corner of the card where it is most susceptible to bending.

Using another rule die, cruciform shapes are cut out of the assembly to give each printed circuit the shape illustrated in Figure 3. This removes the epoxy/glass substrate from those areas which are to become the corners of the finished cards. It is notably these corner parts which are most subject to the type of manipulation which encourages de-lamination.

The printed circuit 1 with reinforced element 19 is now placed, as shown in

Figure 11, between two outer sheets 37 and 38 of thermo plastics material in the pvc family with the inter-position of polyester layers coated on both sides with a thermally activated catalyst adhesive 21. The assembled sandwich is placed in a press where it is heated to cause lamination. During this stage the capsules 18 imbed themselves in each of the sheets of thermo-plastic material in such a way as to tend to centralise themselves between opposite faces leaving the plane of the substrate sheet 1 on the central axis as shown in Figure 4. The press now opens and the assembly is removed to a cutting machine where the individual cards as illustrated in Figures 2 and 3 are cut out.

CLAIMS

1. A flexible card comprising: a printed circuit; outer protective layers in which the printed circuit is sandwiched; and a sheet of reinforcing material located between the circuit and one of the protective layers.

2. A card as claimed in claim 1 wherein the reinforcing material is polyester.

3. A card as claimed in claim 1 or claim 2 wherein the reinforcing layer is coated in adhesive which bonds a protective layer to the printed circuit.

4. A card as claimed in claim 3 wherein the adhesive is a thermally activated catalytic curing adhesive.

5. A card as claimed in any preceding claim comprising a reinforcing layer between each of the protective layers.

6. A card as claimed in any preceding claim wherein one or more components are located on the printed circuit.

7. A card as claimed in any preceding claim wherein one or more components are encased in a relatively hard encapsulant material to form an element.

8. A card as claimed in claim 7 wherein the element is on a limb of the printed

circuit board.

9. A card as claimed in any preceding claim wherein components on the printed circuit board are embedded in a protective layer.

10. A card substantially as hereinbefore described with reference to Figures 2 and 11 of the accompanying drawings.

11. A method of fabricating a printed circuit having components thereon comprising: sandwiching the printed circuit between inner layers of flexible reinforcing material and outer layers of protective material; and heating the layers such that the outer material softens allowing the components to become embedded in it.

12. A method as claimed in claim 11 wherein the reinforcing layers are coated with adhesive which bonds the protective layers to the printed circuit.

Patents Act 1977
Examiner's report to the Comptroller under Section 17 (The Search Report)

-12-

Application number
GB 9313754.5

Relevant Technical fields

(i) UK Cl (Edition L) B6A (AK)

(ii) Int Cl (Edition 5) G06K

Search Examiner

G J W RUSSELL

Databases (see over)

(i) UK Patent Office

(ii)

Date of Search

6 OCTOBER 1993

Documents considered relevant following a search in respect of claims 1-12

Category (see over)	Identity of document and relevant passages		Relevant to claim(s)
X	GB 2225283 A	(DE LA RUE) - see layers (2, 6) and note thickness table page 3	1
X	EP 0488574 A2	(AT & T) - see column 7 line 46 - column 8 line 51	1-4, 6
X	EP 0216366 A2	(CASIO) - see column 3 line 44 - column 4 line 39	1, 3, 4
X	US 4966857	(GAO) - see column 4 lines 18-68	1, 3, 4

Category	Identity of document and relevant passages -13-	Relevant to claim(s)

Categories of documents

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A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

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&: Member of the same patent family, corresponding document.

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